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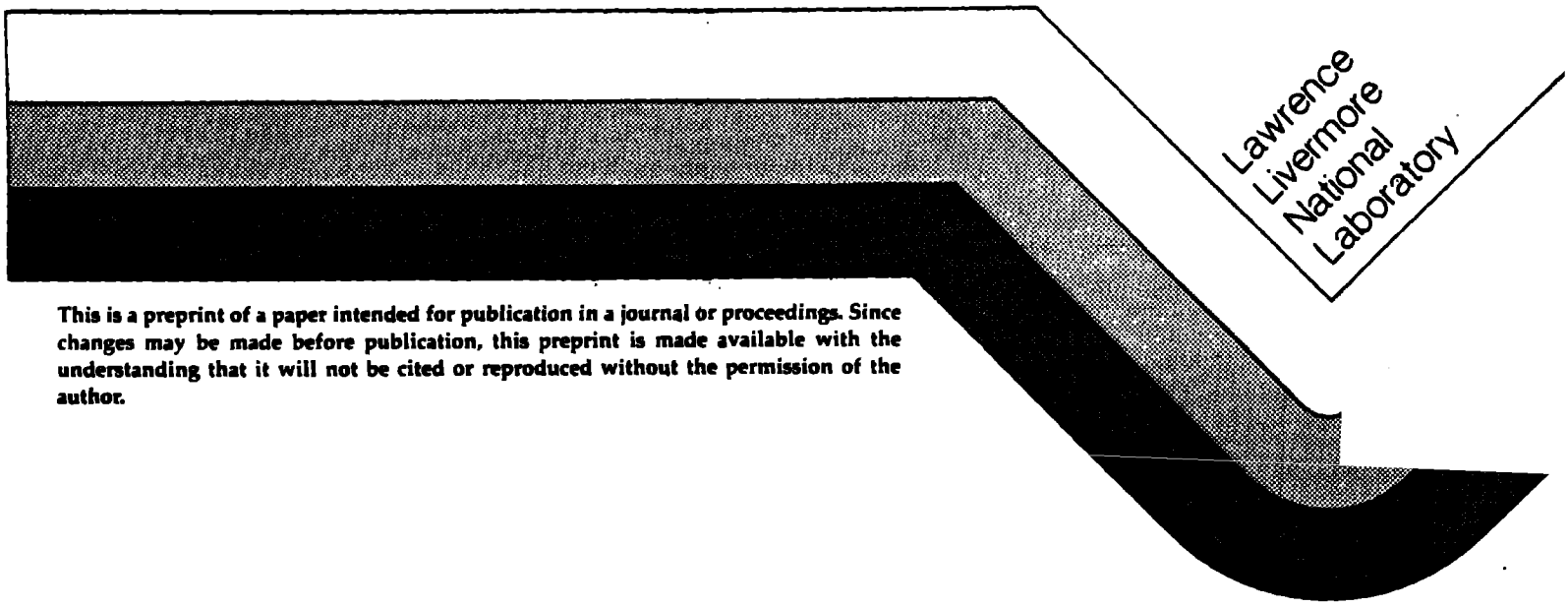

# A Numerical Electromagnetic Engineering Design Station as an Educational Tool*

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## Introduction

The Numerical Electromagnetic Engineering Design System (NEEDS) is a computer aided electromagnetic design and modeling system being developed at Lawrence Livermore National Laboratory. It is being developed to assist the design engineer in using the various modeling codes available by simplifying the model development and output examination. This paper examines the educational applications of the system.

## Background

Present electromagnetic modeling programs are useful but lack the convenience necessary for teaching EM theory or design practices. They are difficult to learn and for many codes, the documentation is poor. Additionally, there is no unifying standard with which the user can define the model being studied or examine the results. These codes are also difficult to use from an instructional viewpoint. It is difficult to analyze large problems due to the quantity of data produced by the codes and there are no general purpose graphics programs to examine the geometrical model, impedance behavior, radiation patterns, etc. The user is forced to learn the modeling code being used as opposed to studying theory or learning practical electromagnetic design techniques.

## Implementation

NEEDS provides an alternative to the present system for electromagnetic instruction. It presently supports the Numerical Electromagnetics Code (NEC) [1] and the Ohio State Basic Scattering Code [2]. It is an easy to learn system, being equipped with an on-line help package. NEEDS is also easy to use. It is a series of pull-down menus and forms, based on developments by the *EAGLES* [3] team at Livermore, which prompt the user for the proper input. There are several packaged graphic displays presently available, a

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model geometry previewer, wire segment current display, Smith chart, and polar radiation pattern plots. Future plans call for expanded capabilities for the existing packages, a near-field contour plot, rectangular pattern plots and current displays, and other graphics as deemed necessary. The model previewer is useful in that it allows the model to be examined for errors before a costly computer run is made and is demonstrated in the examples below.

In teaching electromagnetic theory, the instructor can use NEEDS to design a problem to re-enforce a particular concept. After the course has been taught once using this system, a library of problems is available for the instructor to use in the future. Students examine the theory via the graphic displays and tables and don't necessarily have to become experts in a given modeling code. This promotes more independent thought in implementing new algorithms incorporating electromagnetic theory.

NEEDS can be very useful in teaching electromagnetic design practices such as antenna design. Using the system to find iterative solutions develops students' familiarity with antenna design features such as the effects of coupling to nearby objects and radiation patterns. The relationship between radiation patterns and current distribution is also easily examined. This system has one feature which is highly desirable in the education environment. It is much cheaper than a full scale antenna range. It can act as an electromagnetic laboratory, bringing the capability to teach design practices to a larger number of institutions. It can also be used to show problems with computer modeling as opposed to full scale testing.

## Examples

Figure 1 shows a sample menu and form display in which the wire geometry data is entered. The values entered must fit into pre-defined limits established by the modeling code or the form will not accept them. An error message is displayed in this case and the user is returned to the invalid entry. Figure 2 shows an incomplete wire model which appears to be valid. Figure 3 shows the same model with connected segments (small dots) and free ended wires (dashed lines) indicating that one joint is not connected. This simple demonstration shows how the model previewer can help by allowing the user to check a complicated model before submitting it to the modeling code.

## Conclusions

The development of an engineering workstation for electromagnetic design can ease the difficulties found in teaching this subject by simplifying the tools available to instructors and students. It allows more time to be devoted to the subject at hand, rather than providing a course in any given modeling

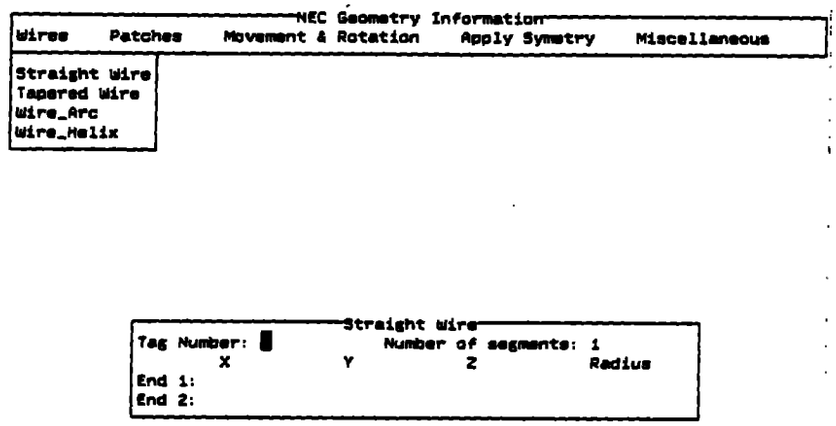


Figure 1. Sample Menu and Form Display

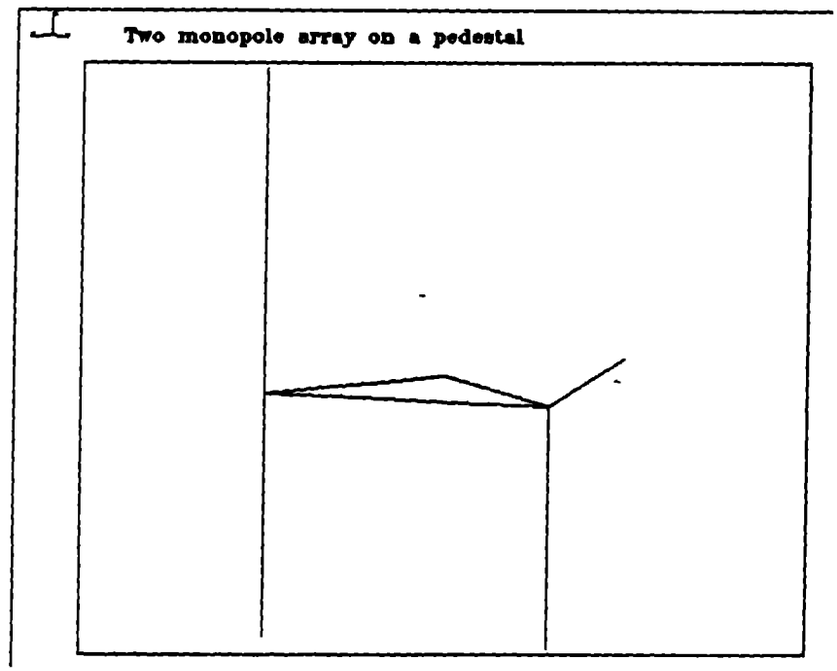


Figure 2. Incomplete Wire Model

code.

## References

[1] G. J. Burke and A. J. Poggio, "Numerical Electromagnetics Code - Method of Moments", NOSC TD 116, Naval Ocean Systems Center, San Diego, CA, Jan. 81

[2] R. J. Marhefka and W. D. Burnside, "Numerical Electromagnetic Code - Basic Scattering Code", Technical Report 712242-14, Ohio State University Electro-Science Laboratory, Dec. 82

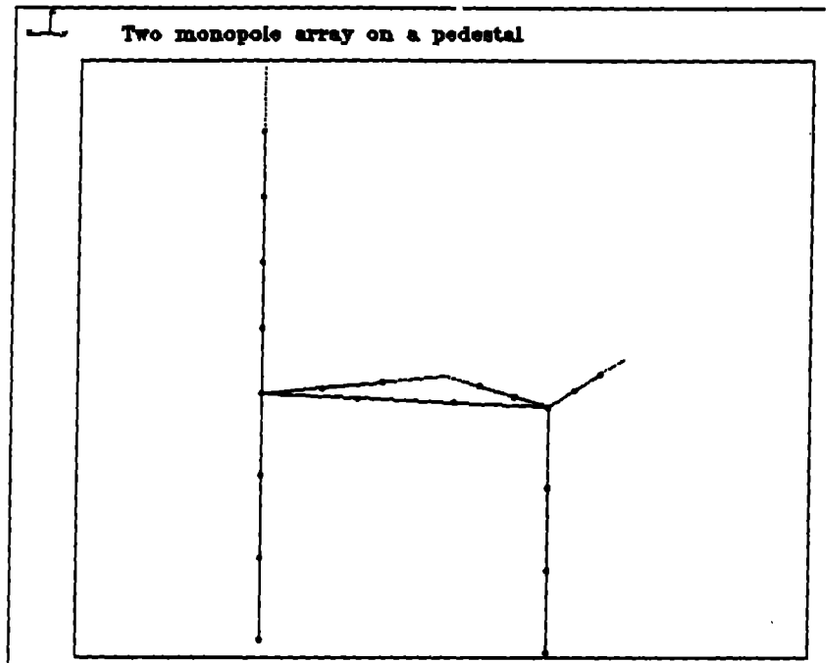


Figure 3. Incomplete Model showing connections and free ends

[3] B. S. Lawver, D. W. O'Brien, and M. E. Poggio, "Code Development with the EAGLES Engineering Problem-Solving Environment", UCID-20666, Lawrence Livermore National Laboratory, Feb. 86